DANIEL R. STEWART
MINING GEOLOGIST
ROUTE 1, BOX 158
WEBB CITY, MISSOURI 64870

TELEPHONE (417) 673-4161

April 27,1989

Mr. Arnold E. Godduhn
Gold Fields Mining Corp.
230 Park Avenue
New York, N.Y. 10169

Re: Map of Oronogo-Dueweg Mining Belt, Showing Underground Workings (Scale 1" = 1,200')

Dear Arnold:

Attached find copy of a base map of the Oronogo-Duenweg Mining Belt, showing the underground mine workings (minus the shallow ground diggings) using the latest known mine surveys.

This map was originally prepared under my direction by the American Zinc Co. in January 1974, to show the past, and then current. land holdings of the Zinc Co.

The present version being submitted is a revision of the original map, with the northen portion being extended one and one half miles northward in order to include the Snapp, and Buckingham-Gibson mines of the St. Joseph Lead Co. Also added is the Needmore mine operated by the Eagle-Picher Co. during World War II.

These revisions required considerable redrafting, plus a scale reduction from 1" = 800' to 1" = 1200', in order to reduce its overall size. I engaged a local engineering company to complete the final tracing.

With this base map boundary lines can be drawn to show property holdings by various mining companies, outlne of the Central Drainage District, water pumping pools, current ore reserve outlines, and site locations for the comptemplated photographs.

After you have had a chance to study this map, the additional information desired can be plotted on duplicate tracings for reproducion. To avoid clutter it will probaly take several tracings to present differing forms of information.

Sincerely yours,

Daniel R. Stewart

Copy to Mitch Bernstein.

MEMORANDUM REPORT
MILLING PRACTICES
ORONOGO-DUENWEG MINING BELT

GENERAL STATEMENT

The milling practices used in the Oronogo-Duenweg Mining Belt, from its beginning in 1850 to its demise in the early 1950's, evolved through many years of trial and error, and resulted in the develoment of the standard-type concentration plant that was adopted throughout the district. The milling methods used here differ somewhat from those in other mining areas of the country in that they were designed to accommodate three different types of ore deposits, all associated with a hard, dense host rock that is difficult to crush and grind.

Because of the "free-milling" characteristics of the ores in this mining belt, gravity separation techniques were used exclusively until the late 1930's. After that date minor tonnages of fine grained "disseminated" ore, and gravity milling fines, were treated by differential flotation processes.

It is estimated that from the 108 million tons of crude ore milled in this mineralized belt, approximately 300,000 tons, or 0.3 percent of the total tonnage, were treated by flotation methods at locally sited mills.

In order to more fully understand the concentration procedures, a brief summary of the (1) Character of the Ores, (2) Milling Methods, and (3) Milling History, is presented below.

CHARACTER OF THE ORES

The ore deposits of the Tri-State district are unique in that they occur in a very refractory host rock, consisting of massive beds of both brecciated and stratified chert. The mineral chert is a hard, dense, cryptocrystalline variey of quartz, having a Moh's Scale hardness if 7 (harder than steel). Such rocks are extremely tough, but brittle under heavy impact, breaking with a conchoidal fracture, and are resistant to most acids and bases. Due to its hard, abrasive nature, chert is very difficult, and expensive, to crush and grind to small-sized fractions. Because of these characteristics it is more economical to recover the ore minerals at the coarsest possible grain sizes by gravity separation milling equipment.

From an ore dressing standpoint the ore deposits of the district can be classified into two general types: (1) the "free-milling" ores, where the sulfide ore minerals occur as cementing material in the brecciated, and/or stratified zones of primary chert; and (2) the "disseminated" ores, where the sulfide ore minerals occur as minute grains embedded in zones of secondary cherty jasperoid. The ratios betwen the "free-milling" and "disseminated" ores vary throughout the district, with some of the subdistricts, such as the Picher-Treece areas of Oklahoma and Kansas, having a mixture of both types.

Fortunately most of the ore bodies in the Oronogo-Duenweg Mining Belt are of the "free-milling" type, where metallic concentrate recoveries in the 80 to 90 percent range can be obtained through the exclusive use of gravity-type milling techniques.

In those subdistricts having ore occurrences of both types, gravity separatiion processes are not highly efficient, with concentrate recoveries being as low as 70 to 80 percent. It was in these subdistricts that, after 1924, techniques were developed to remove the "disseminated" (chatty) ore fractions from the gravity circuits for finer grinding and processing by flotation methods. Through this arrangement mill recoveries were increased by appoximately 10 percent, with concentrate production being about 80 percent from gravity separation, and 20 percent from flotation treatment.

MILLING METHODS

Gravity Separation

In gravity-type milling the crude ore is crushed to only those size ranges that allow the sulfide ore minerals to break free from their gangue rocks. At this point the crushed material is screened to proper size ranges for further treatment by mecnanically powered pulsating and vibrating equipment. The coaser sized particles are processed in a vertical column of pulsating water (jigging), while the finer sizes are treated on horizontally-vibrating tables (tabling).

Jigging. -- From 70 to 80 percent of the metallic concentrates produced in the district are derived from jigging techniques. In this process the mill feed is crushed and screened to a size of 3/8 to 5/8 inch, and passed to a series of containers where it is pulsated by a vertical column of water. By this action the heavy minerals settle to the bottom, and are drawn off, with the lighter fractions being rejected as tailings. An apparatus of this type can be either hand-powered, or mechanically powered, with large mills having several batteries of these units. After repeated cycles on different sized screens, a satisfactory concentrate, a middling product, and a near barren tailing product are produced.

Tabling. -- The tabling process follows the jigging operation, and utilizes the reground material from the middling product of the jigging. This reground material after screening ranges is size from about 20 to 65-mesh, and is passed with water over tilted concentrating tables, containing riffles, where it is subjected to quick horizontal pulsations. This operation, after repeated cycles, produces a concentrate, a middling product, and tailings for discard. As a general rule from 8 to 15 percent of the concentrates produced from a gravity-type mill are from the tabling operation.

Differential Flotation

The use of differential flotation techniques is comparitvely new in the Tr-State District, having been experimented with in 1915, but due to patent litigation did not become of significant importance until 1924. Even after its introduction, its use was limited to the treatment of only 10 to 20 percent of the crude ore feed, and was of economic value for only those ores containing appreciable quantities of "disseminated" sulfides.

In this process the finely ground flotation feed is combined with previously formed fine sands and slimes from the gravity milling, and mixed with water containing small quantities of organic oils and other chemicals. This fine grained pulp is then passed through a series of flotation cells, where it is agitated to form a froth of air bubbles coated with oil. The sulfide ore minerals adhear to such bubbles, and are carried upward and swept into a collecting trough. With the addition of copper sulfate, and/or zinc sulfate, and through various recycling stages, satisfactory concentrates of zinc and/or lead can be produced.

This process involves no chemical reactions, and is base solely on the physical attraction of the metallic sulfides to the surfaces of the oil coated air bubbles.

Reagents commonly used in the floation process consist of cresylic acid or pine oil for frothers; potassium ethyl xanthate, sodium Aeroflot, or Aeroflot Nos. 15 and 25 for collectors; Barrett No. 634 as a froth conditioner; copper sulfate as a zinc activator, and occassionally a little sodium silicate as a depressing agent. For the most part these reagents are organic compounds, with relatively small quantities being discharged to tailings ponds by wash water.

MILLING HISTORY

Because of typically low grade values of the ore deposits, requiring from 25 to 30 tons of crude ore to produce one ton of concentrates, some economical method of upgrading has been a necessity. During the early years of mining most of the ore cleaning was done by hand-cobbing, and was later supplemented by hand-jigging. Mechanized milling was not common until the 1870's, when steam-power came into general use. By 1900 the fully mechanized gravity separation mills came into use in the Webb City area, capable of treating up to 50 tons per hour, and were later copied as the standard milling facility of the district.

A table showing the productive periods in the Oronogo-Duenweg Mining Belt is as follows:

Operating Period	Type of Ore Deposit Milled	Est. Tons Milled (Thousands)	Percent of Total
1850-1880	Upper-Ground	2,000	2
1881-1897	Breccia-Ground	16,000	15
1898-1918	Sheet-Ground	79,000	73
1919-1934	Upper & Breccia	2,000	2
1935-1952 ?	Sheet & Breccia	9,000	8
	Totals	108,000	100

A brief summary of the milling procedures utilized during each of the above operating periods is as follows:

Early Period (1850-1880). -- This thirty year period marked the beginning of mining, and was characterized as a time of shallow ground diggings to depths not exceeding 100 feet, by hundreds of small mining outfits. Ore dressing, after hand crushing with sledge hammers, was confined to hand-jigging, ranging from one jig to batteries of hand-jigs operated by dozens of men. With repeated jigging and washing, a good grade of concentrates was produced, although the tailing losses were conparitively high.

Intermediate Period (1881-1897). -- This sixteen year period was the time when steam-power became into general use. Steam engines were first used for mine pumping, but were later adapted for power crushing, grinding, and jigging. Mining depths were extended downward to the 175-foot levels for the development of the hard ground, breccia ore deposits. Great advances were made in mine mechanization, with mine production exceeding one million tons per year, or some 16 million tons for the period.

Boom Years (1898-1918). -- With the mechanization of both mining and milling methods, plus the introduction of the gravity separation tables, and electric power, mining operations were extended downward to the Sheet-Ground levels, averaging 200 feet in depth. Although the Sheet-Ground ore was very low grade, averaging around 2 percent as recoverable metal, its horizontal continuity provided for large tonnage mining operations. Mine production boomed, averaging about 4 million tons per year, or some 79 million tons for the 20 year period. By 1918, 146 fully mechanized concentration plants were operating, each with daily capacities exceeding 1,000 tons.

Depressed Years (1919-1934). -- This period began with the collaspe of metal prices following World War I, and continued into the Depreeeion Years of the 1930's. With the low grade Sheet-Ground ore being uneconomical to mine, most of the large concentrating plants were dismantled and moved to the new ore discoveries in Oklahoma and Kansas. Mining activity slumped to around 80,000 tons per year, or about 2 million tons for this 25 year perion. The few remaining mills were small crude affairs, producing small quantities of jig and table concentrates for shallow ground operators.

World War II Years (1935-1952) ?. -- During the Depression Years, and extending through the World War II period, efforts were made to reactivate the Oronogo-Duenweg Mining Belt. This work consisted of dewatering the entire mining belt, and with the aid of the U.S. Government's mine subsidy programs, resulted in the resumption of mining to the Sheet-Ground levels in the

Oronogo and Duenweg vicinities. During this 17 year period some 9 million tons if crude ore was milled, averaging about 500,000 tons per year.

It is interest to note that during this period approximately two-thirds of the tonnage produced was hauled by railroad to the large central mill of Eagle-Picher Co. in Oklahoma. The remaining one-third, or about 3 million tons, was treated at new concentrating plants erected at Oronogo and Duenweg. These locally sited plants could treat approximately 50 tons per hour, and were equipped with flotation circuits to treat fine grained mill feed.

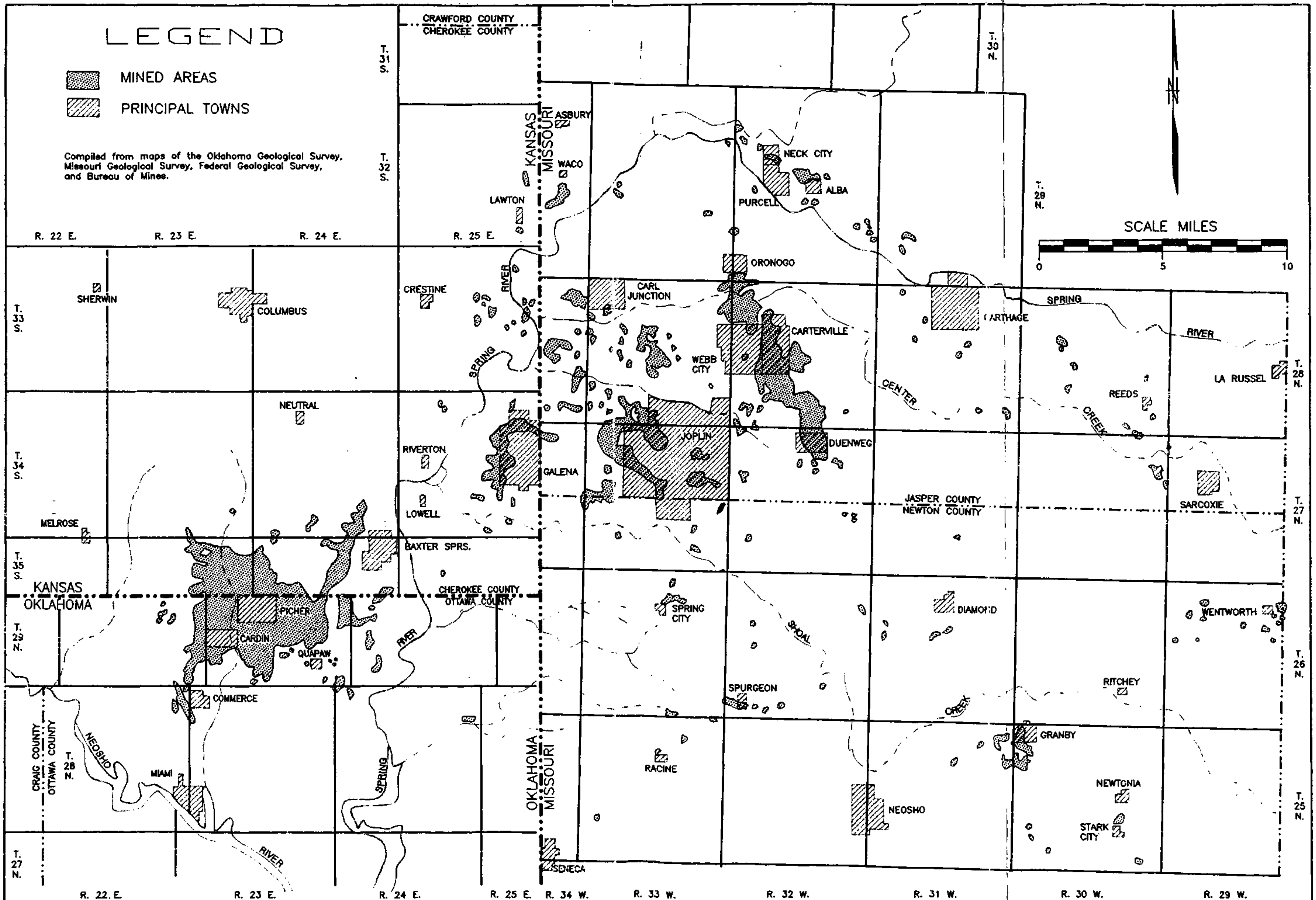
The flotation concentrates produced at these Oronogo and Duenweg mills were the only flotation products to come from the Oronogo-Duenweg Mining Belt since its inception in 1850. Of the 3 million tons locally milled during this period, approximately 10 percent, or about 300,000 tons, were treated by flotation circuits. When comparing the mill tonnages treated by flotation methods with the mill tonnages treated by gravity separation over the life of this mining belt, it is evident that the mill tonnage subjected to flotation treatment constitutes only 0.3 percent of the total tons milled.

From such a small tonnage of milled ore treated by flotation methods, concerns regarding possible pollution from flotation reagents appears to be vastly exaggerated.

Daniel R. Stewart

March 2, 1989

Daniel R. Stewart
Rt. 1, Box 158
Webb City. Mo.



Principal Part of Tri-State Zinc-Lead District, Showing Mined Areas.

Figure I-I

Jasper County
TR100879